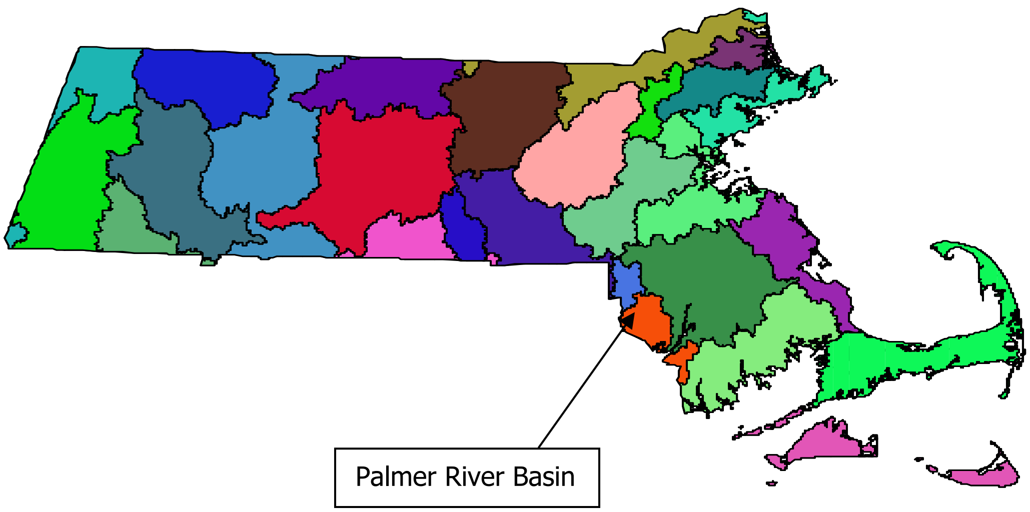
DRAFT BACTERIA TMDL FOR THE PALMER RIVER BASIN
Draft Report MA 01-06/MWI



COMMONWEALTH OF MASSACHUSETTS
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ACKNOWLEDGMENT

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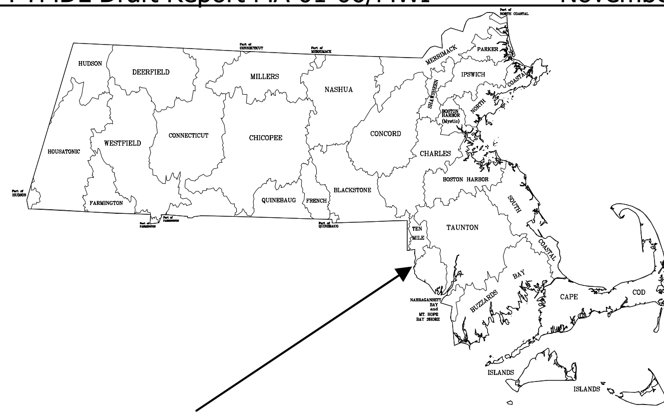
Draft Total Maximum Daily Loads of Bacteria for
Palmer River Basin

DEP, DWM TMDL Draft Report MA 01-06/MWI November 26, 2003



Location of the Palmer River Basin in Massachusetts.

Key Feature:	**Fecal Coliform Bacteria TMDL for the Palmer River Watershed.**
Location:	**EPA Region 1.**
Land Type:	**New England Upland**
303d Listings:	**Pathogens (MA53-03, from the Route 6 bridge in Rehoboth to the State Line; MA53-04, from the confluence of the East and West Branches of the Palmer River to the Shad Factory Pond dam, Rehoboth; MA53-05, from Shad Factory Pond dam to Route 6 bridge, Rehoboth).**
Data Sources:	**Massachusetts Department of Environmental Protection, Massachusetts Division of Marine Fisheries, Rhode Island Department of Environmental Management, MassGIS.**
Data Mechanism:	**Massachusetts Surface Water Quality Standards for Fecal Coliform, Ambient Data, and Best Professional Judgment**
Monitoring Plan:	**Massachusetts Watershed Five-Year Cycle**
Control Measures:	**Watershed Management, Storm Water Management, Agricultural Best Management Practices, and Septic System Maintenance.**

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EXECUTIVE SUMMARY

Background

This report presents a Total Maximum Daily Load (TMDL) for bacteria in the Massachusetts portion of the Palmer River and its tributaries (see Figures A and 1 through 4). The Palmer River is tributary to the Narragansett and Mount Hope Bays. This TMDL is required under Section 303(d) of the Federal Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130). The CWA requires states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies and to develop TMDLs for listed waters and the pollutant(s) contributing to the impairment.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Palmer River and its tributaries. These include water supply, shellfish harvesting, fishing, boating, and swimming. The waters of Shad Factory Pond, Anawam (Upper Warren) Reservoir, and the stream connecting the two are used as a public drinking water supply for the Bristol County Water Authority – the terminal reservoir is in Warren, Rhode Island. With regard to shellfish habitat, the Massachusetts Division of Marine Fisheries (MDMF) has designated shellfish beds up to the Shad Factory Pond dam (upstream of Site PM08), the extent of tidal influence in the watershed, and there are designated shellfish beds in the downstream Rhode Island waters. Massachusetts also wishes to maximize the value of the Rhode Island sampling efforts (discussed below in Section 4.1).

The Palmer River watershed is one of the primary sub-drainage areas within the Narragansett and Mount Hope Bays watershed. The Palmer River converges with the Barrington River in the towns of Warren and Barrington, Rhode Island to form the Warren River, which is a tributary estuary to upper Narragansett Bay. The Massachusetts portion of the Palmer River watershed falls primarily within the municipalities of Rehoboth and Swansea, Massachusetts. The watershed is predominantly forested, but has substantial land areas dedicated to residential, agricultural, and recreational use.

Evaluation Approach

Much of the data used to develop this TMDL was collected during sampling efforts conducted in 2001 and 2002, with results reported in the Nonpoint Source Pollution Management Plan for the Ten Mile River/Narragansett and Mount Hope Bays Watersheds (ESS, 2003A). A total of 88 sample stations were evaluated in the Palmer River watershed (see Appendix A). The Palmer River Microbial Source Tracking (MST) Study (ESS, 2003B) was also conducted as part of this NPS assessment. The MST study focused on a select set of Palmer River watershed sub-basins and used DNA ribotyping to identify sources of fecal-borne contamination.

The Palmer River and its tributaries, from headwaters to the outlet of Shad Factory Pond, are classified as Class B waters (314 CMR 4.06) and the fecal coliform standard is a geometric mean of 200 cfu/100 ml and no more than 10% shall exceed 400 cfu/100 ml. Below the Shad Factory Dam, the Palmer River is designated Class SA and the fecal coliform standard is a geometric mean of 14 cfu/100 ml and no more than 10% shall exceed 43cfu/100 ml (MADEP, 2004).

Fecal Coliform Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Palmer River and Identified Tributary Streams

Bacteria Source Category	WLA (organisms/100ml)	LA (organisms/100ml)
Failing Septic Systems	0	0
Direct Wildlife	--	Geomean $\leq$ 200 10% $\leq$ 400 (Class B) or Geomean $\leq$ 14 10% $\leq$ 43 (Class SA)
Livestock	--	0
Stormwater Runoff	Geomean $\leq$ 200 10% $\leq$ 400	Geomean $\leq$ 200 10% $\leq$ 400 (Class B) or Geomean $\leq$ 14 10% $\leq$ 43 (Class SA)

Problem Assessment

An analysis of all validated data collected by ESS, MADEP, MDMF, and RIDEM between 1997 and 2002 is presented in Table 2 in Section 4.2.2 below. Review of these data indicates violations of the Massachusetts bacteria standard (i.e., pathogens) occur regularly during wet and dry weather in the three Palmer River mainstem segments listed for pathogens on the *Massachusetts Year 2002 List of Integrated Waters* (MADEP, 2002) – sometimes referred to as the "303(d) list" – as well as numerous other water body segments in the basin. These 303(d) listed segments have violated water quality standards during the period reviewed for at least one sample location:

- MA53-03, from the Route 6 bridge in Rehoboth to the State Line;
- MA53-04, from the confluence of the East and West Branches of the Palmer River to the Shad Factory Pond dam, Rehoboth; and
- MA53-05, from Shad Factory Pond dam to Route 6 bridge, Rehoboth).

Conclusions

An analysis of fecal coliform concentration results from each sample location studied is presented in Table 2 (Section 4.2.2). Table 2 includes target concentrations and reductions necessary to meet water quality goals. Sample stations evaluated are shown in Figure 4. Sample stations within segment MA53-03 at which violations of the Massachusetts bacteria standard were observed include PM25 (Palmer Mainstem – unnamed salt marsh creek in Swansea). Sample stations within segment MA53-05 at which violations of the Massachusetts bacteria standard were observed include PM08 (Palmer Mainstem – outlet of Shad Factory Pond), PM14 (Palmer Mainstem – tributary below Shad Factory Pond), PM26 (Palmer Mainstem in Rehoboth), PM10 (Palmer Mainstem in Rehoboth), and PM11 (Palmer Mainstem – Bungtown Bridge in Swansea). No violations of the Massachusetts bacteria standard were observed in segment MA53-04. However, numerous violations were observed in tributaries to this segment (see Section 4.2.2).

This TMDL applies not only to those segments within the Palmer River basin that appear on the 1998 303(d) list for pathogen violations, but also to all segments in this basin that are identified as being impaired by pathogens through the evaluation of water quality monitoring data as presented in this report. Other water body segments in the Palmer River watershed in which violations of the Massachusetts bacteria standard were observed include:

- Palmer River-West Branch (PW01, PW05, BA01, BA02, and BA03),
- Palmer River-East Branch (PE04, PE06, and PE09),
- Rumney Marsh Brook (RB01 and RB02),
- Beaver Dam Brook (BB01),
- Bad Luck Brook (BL01 and BL02),
- Fullers Brook (FB02, FB03, and FB04),
- Clear Run (CR01, CR02, CR03 and CR07),
- Torrey Creek (especially TC01),
- Old Swamp Brook (OS01 and OS04), and
- Rocky Run (RR05, RR06, and RR07).

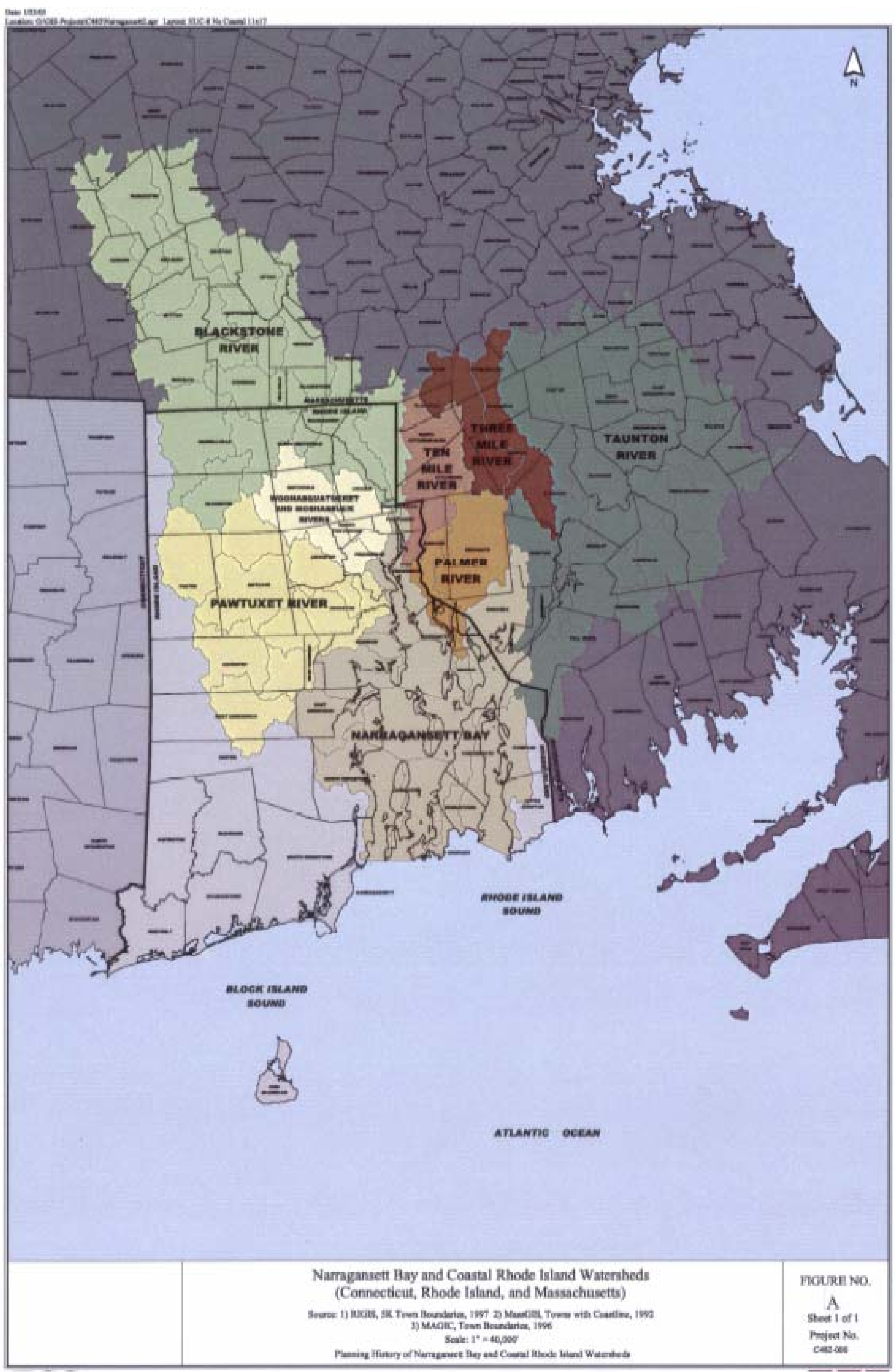
In total, of the 88 Palmer River watershed sample stations included in the NPS study, water quality at 33 stations violated Massachusetts bacteria standards (see Table 2 and Appendices A and B). The most severe violations of these standards (potential "hot spots"), listed in order of severity, occurred at:

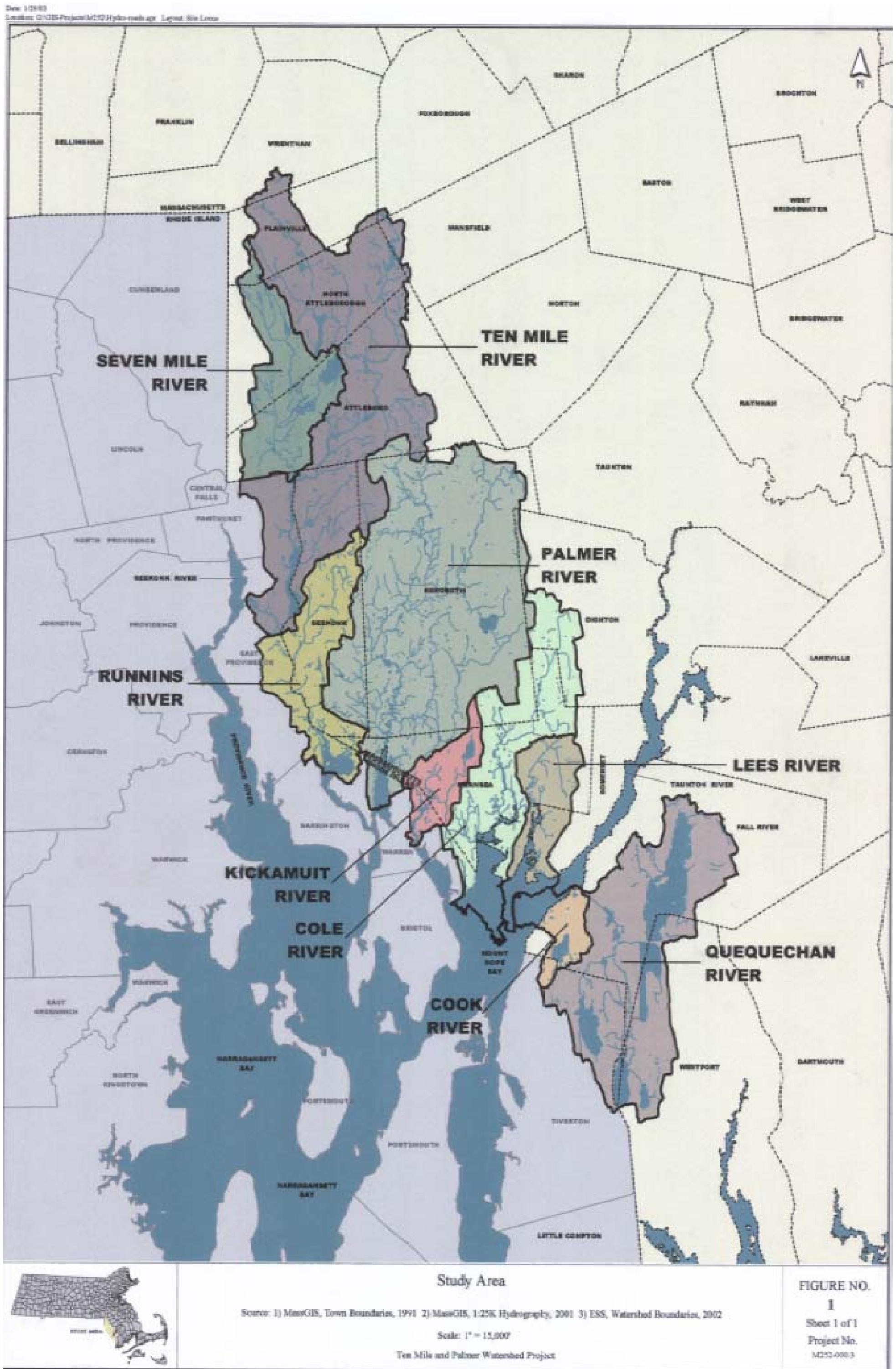
- FB02 and FB03 (Fullers Brook);
- CR03 (Clear Run Brook);
- TC01 (Torrey Creek);
- RB02 (Rumney Marsh Brook);

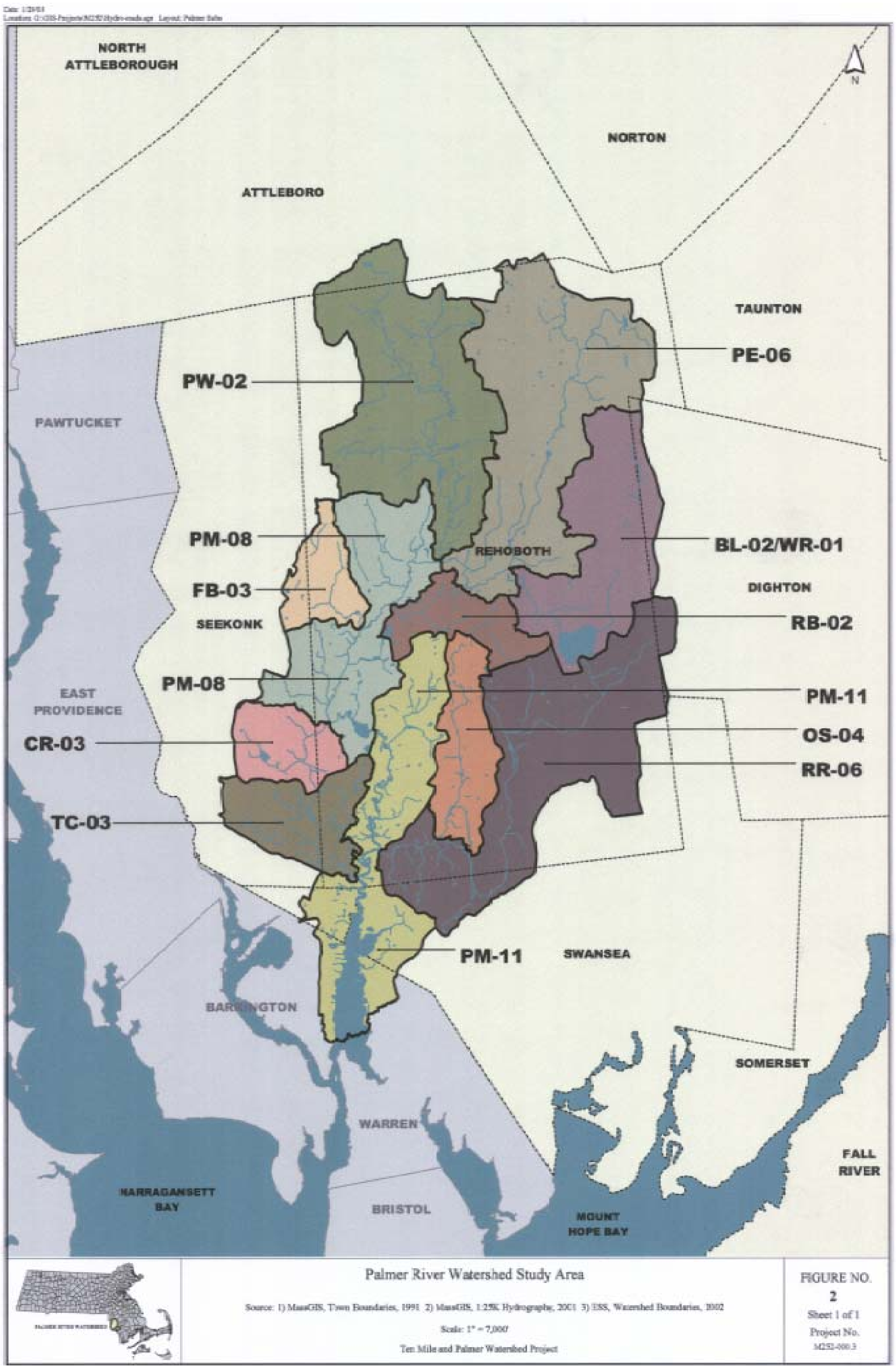
- CR02 (Clear Run Brook);
- RR05 (Rocky Run); and
- PM08, PM26, PM10, PM11, PM25 (Palmer Mainstem downstream of Shad Factory Pond dam).

Summary Table B in Appendix B summarizes the river segments that are impaired due to measured fecal coliform contamination and identifies suspected and known sources to these segments and their tributaries, as identified by ESS (2003A). Several sub-basins in the Palmer River watershed stand out as likely priority areas to address bacteria pollution sources. These sub-basins tend to be located in the southern and western portions of the watershed, where relatively dense residential development is increasing, major roads and highways are present, intensive agriculture is practiced, golf courses and the waterfowl that frequent them are plentiful, and stream channels are less buffered by forested or otherwise vegetated zones than they are in the upper Palmer.

To address these problems, implementation measures (discussed in Section 8.0) are recommended which include correction of failing septic systems, agricultural BMPs, and wildfowl control measures. Documentation of storm drain outfall locations, education of watershed residents (e.g., for proper pet waste management), structural BMPs for controlling runoff from impervious surfaces such as increased buffers, infiltration encouraging devices, or in-line detention facility incorporation into the stormwater system should also be considered.


BLACKSTONE RIVER
TEN MILE RIVER
THREE MILE RIVER
TAUNTON RIVER
WOONASQUATUCKET AND MOSHASSUCK RIVERS
PALMER RIVER
PAWTUXET RIVER
NARRAGANSETT BAY
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
ATLANTIC OCEAN
N
Narragansett Bay and Coastal Rhode Island Watersheds
(Connecticut, Rhode Island, and Massachusetts)
Source: 1) RIGIS, 5K Town Boundaries, 1997 2) MassGIS, Towns with Coastline, 1992
3) MAGIC, Town Boundaries, 1996
Scale: 1" = 40,000'
Planning History of Narragansett Bay and Coastal Rhode Island Watersheds
FIGURE NO.
A
Sheet 1 of 1
Project No.


TEN MILE RIVER
SEVEN MILE RIVER
PALMER RIVER
RUNNINS RIVER
LEES RIVER
KICKAMUIT RIVER
COLE RIVER
QUEQUECHAN RIVER
COOK RIVER
Study Area
Source: 1) MassGIS, Town Boundaries, 1991 2) MassGIS, 1:25K Hydrography, 2001 3) ESS, Watershed Boundaries, 2002
Scale: 1" = 15,000'
Ten Mile and Palmer Watershed Project
FIGURE NO.
1
Sheet 1 of 1
Project No.



Palmer River Watershed Study Area

Source: 1) MassGIS, Town Boundaries, 1991 2) MassGIS, 1:25K Hydrography, 2001 3) ESS, Watershed Boundaries, 2002

Scale: 1" = 7,000'

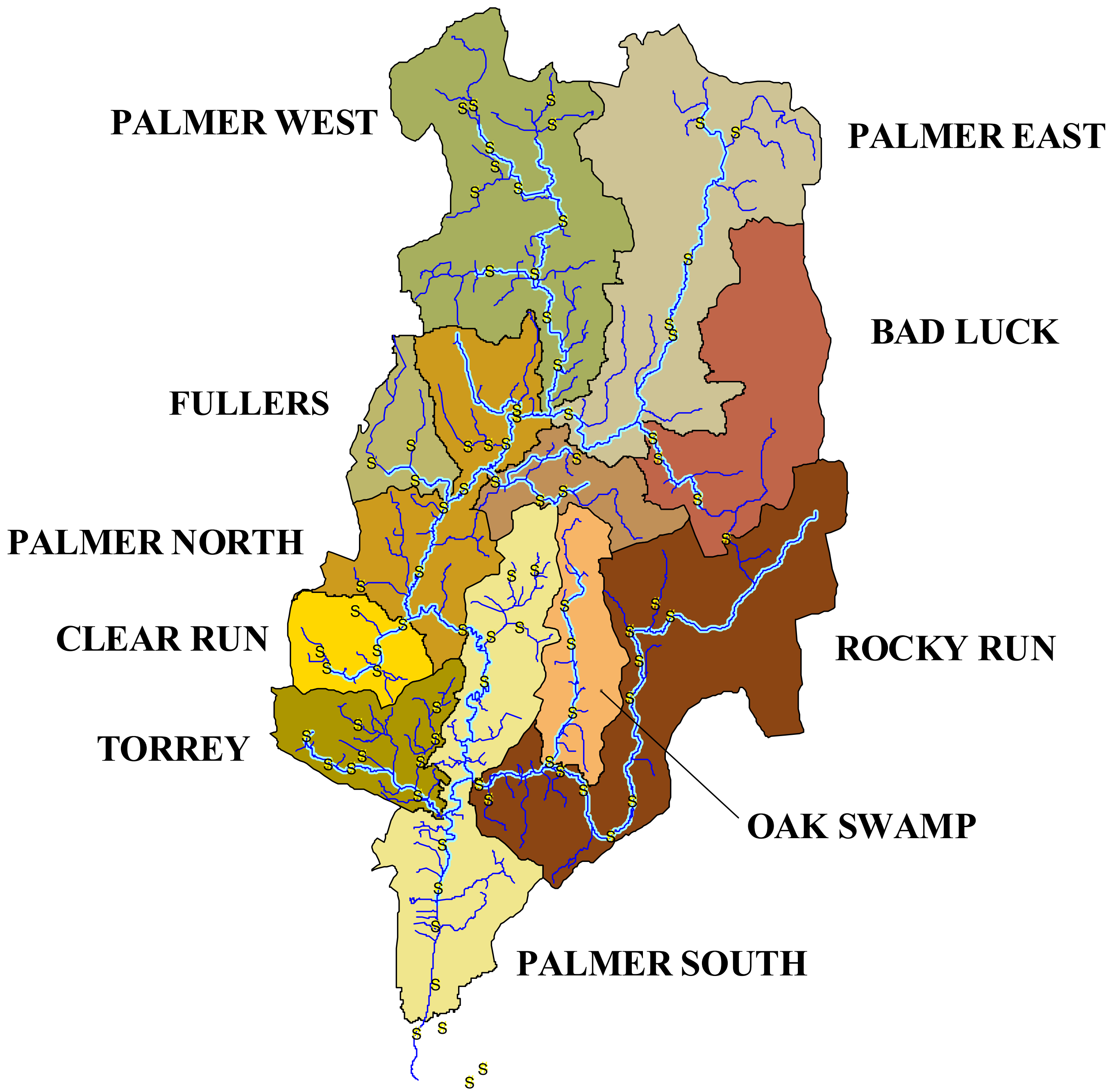
Ten Mile and Palmer Watershed Project

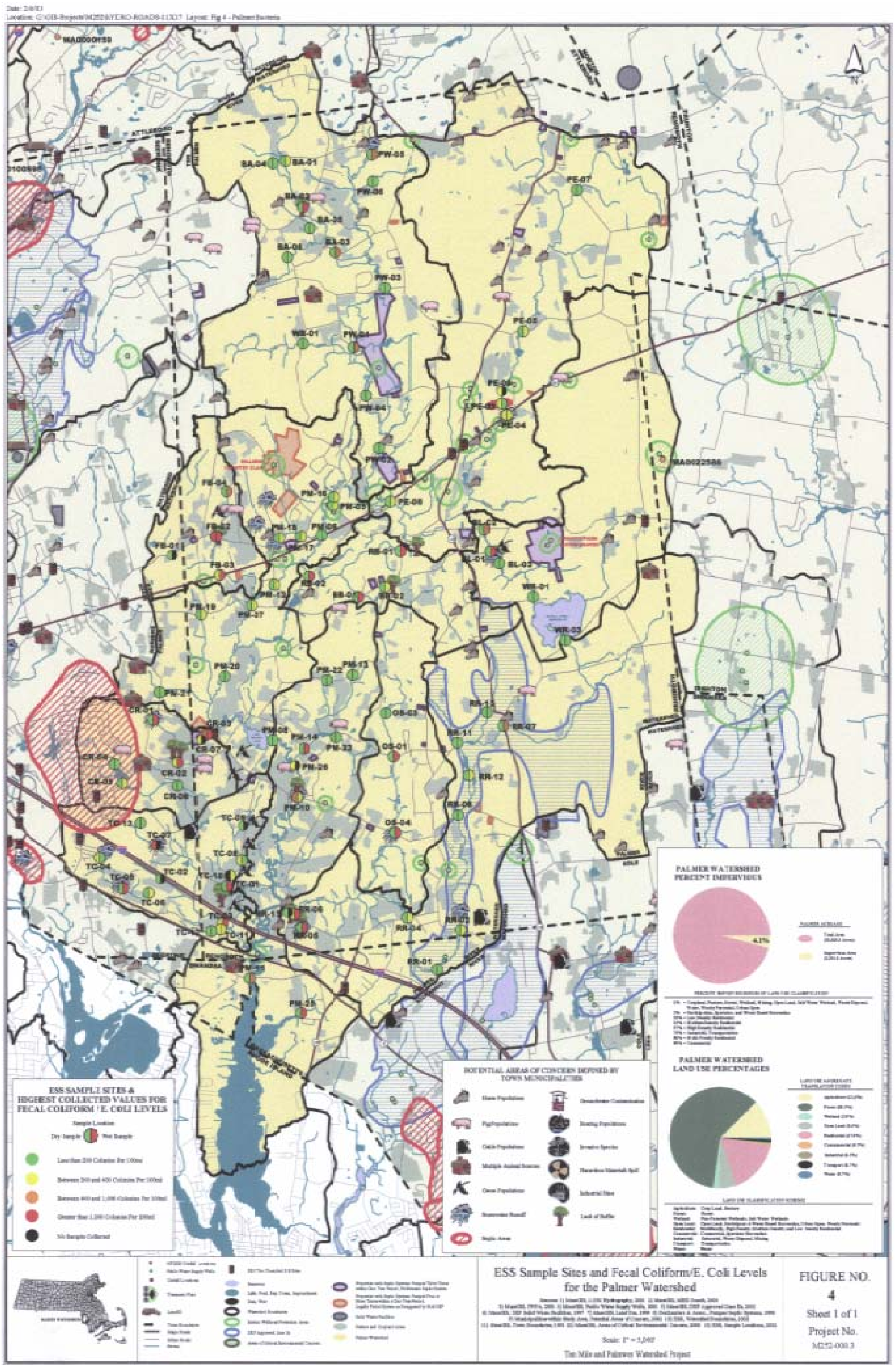
FIGURE NO. 2

Sheet 1 of 1

Project No. M252-000.3

FIGURE 3. Palmer River Watershed





PALMER WATERSHED
PERCENT IMPERVIOUS
4.1%
PALMER WATERSHED
LAND USE PERCENTAGES
POTENTIAL AREAS OF CONCERN DEFINED BY
TOWN MUNICIPALITIES
ESS SAMPLE SITES &
HIGHEST COLLECTED VALUES FOR
FECAL COLIFORM / E. COLI LEVELS
ESS Sample Sites and Fecal Coliform/E. Coli Levels
for the Palmer Watershed
FIGURE NO.
4
Sheet 1 of 1
Project No.

1.0 INTRODUCTION

1.1 Background

TOTAL MAXIMUM DAILY LOADS (TMDL)?

A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Section 303(d) of the Federal Clean Water Act (CWA) and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA, 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Palmer River and its tributaries. These include water supply, shellfish harvesting, fishing, boating, and swimming. The waters of Shad Factory Pond, Anawam (Upper Warren) Reservoir, and the stream connecting the two are used as a public drinking water supply for the Bristol County Water Authority – the terminal reservoir is in Warren, Rhode Island. With regard to shellfish habitat, the Massachusetts Division of Marine Fisheries (MDMF) has designated shellfish beds up to the Shad Factory Pond dam (upstream of Site PM08), the extent of tidal influence in the watershed, and there are designated shellfish beds in the downstream Rhode Island waters. Massachusetts also wishes to maximize the value of the Rhode Island sampling efforts (discussed below in Section 4.1). In 2002, the Rhode Island Department of Environmental Management (RIDEM) completed a bacteria TMDL for the Palmer River in Rhode Island (RIDEM, 2002). That effort fostered dialogue between Massachusetts and Rhode Island focused on improving water quality on both sides of the state line.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local problem areas or "hot spots" which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the Massachusetts Watershed Initiative (MWI) and the Department of Environmental Protection (MADEP) commissioned the Nonpoint Source Pollution Management Plan for the Ten Mile River/Narragansett and Mount Hope Bays Watersheds (ESS, 2003A).

The assessment was initiated in spring 2001 at the request of local, state, regional, and federal stakeholders participating in a watershed planning process for these basins. This process was centered around Watershed Teams that were coordinated as part of the MWI, formerly a program of the Massachusetts Executive Office of Environmental Affairs (EOEA). The MWI grant that supported this Project was administered through the MADEP, which was also a key manager and technical advisor to the assessment.

As part of this assessment, significant sources of nonpoint source pollution were identified and prioritized and a management plan was developed recommending specific actions to protect and improve water quality in the Ten Mile River/Narragansett and Mount Hope Bay watersheds, including the Palmer River watershed. The underlying purpose of the assessment was to minimize, reduce, and prevent pollution from harming the environment. A further goal of the assessment was to characterize the Massachusetts portion of the Palmer River watershed in anticipation of future development of TMDLs for bacteria and/or nutrients. The assessment represents one component of a watershed protection process undertaken by the EOEA, MADEP, local government, non-governmental organizations, and ordinary citizens.

The Palmer River elements of the assessment were designed to identify specific reaches and tributaries of the Palmer River that are not meeting state water quality standards, identify significant sources of bacteria, and quantify the relative contribution of each pollutant source category to downstream water bodies. A study of nutrients in the Palmer River watershed (ESS, 2003A) was also conducted to determine if the mainstem segment of the Palmer River should remain on the *Massachusetts Year 2002 List of Integrated Waters* (MADEP, 2002) – sometimes referred to as the "303(d) list" – for nutrients (i.e., phosphorus and nitrogen) and, if so, provide the basis for the development of nutrient TMDLs. Phosphorus and nitrogen inputs were targeted for assessment since elevated levels of these nutrients are generally associated with increases in algal production and a subsequent decrease in dissolved oxygen levels, conditions which detrimentally affect aquatic habitat quality.

A variety of assessment methods were applied to achieve the goals of the assessment. These included historical research on past water quality data and pollution sources; field sampling of bacterial, nutrient, and physical parameters; field reconnaissance of stream corridors to determine watershed conditions and identify potential NPS pollution contribution areas; both watershed-based and in stream pollutant load modeling; DNA ribotyping to differentiate bacteria sources in select locations; a survey of failing septic systems in close proximity to rivers and streams in the study area; interviews with local, state, and regional officials; and extensive GIS mapping of the study area and potential nonpoint source pollution contribution areas.

Water quality monitoring data considered in the development of this Palmer River Bacteria TMDL Report include data collected by ESS (2003A), MADEP (unpublished data, 1999), Massachusetts Division of Marine Fisheries (MDMF, 1997), and Rhode Island Department of Environmental Management (RIDEM, 2002).

RIDEM completed a bacteria TMDL for the Rhode Island portion of the Palmer River in 2002 (RIDEM, 2002). The water quality goal set in the Rhode Island bacteria TMDL at the state line was the Class SA standard, 14 cfu/100 ml with a 90th percentile of 49 cfu/100 ml (see Section 3.0 below).

1.2 Palmer River Basin

Situated in Massachusetts and Rhode Island, the Narragansett and Mt. Hope Bays (Figure A) and their estuaries form one of the largest and most ecologically significant aquatic ecosystems in the region, providing habitat for numerous bird species; supporting large populations of hard and soft-shell clams, blue crabs, and oysters; providing a major recreational resource; and contributing significantly to local and regional economies. The Narragansett and Mt. Hope Bays watershed has a drainage area of 1,850 square miles, 61% of which is in Massachusetts. The Narragansett Bay is designated as an Estuary of National Significance.

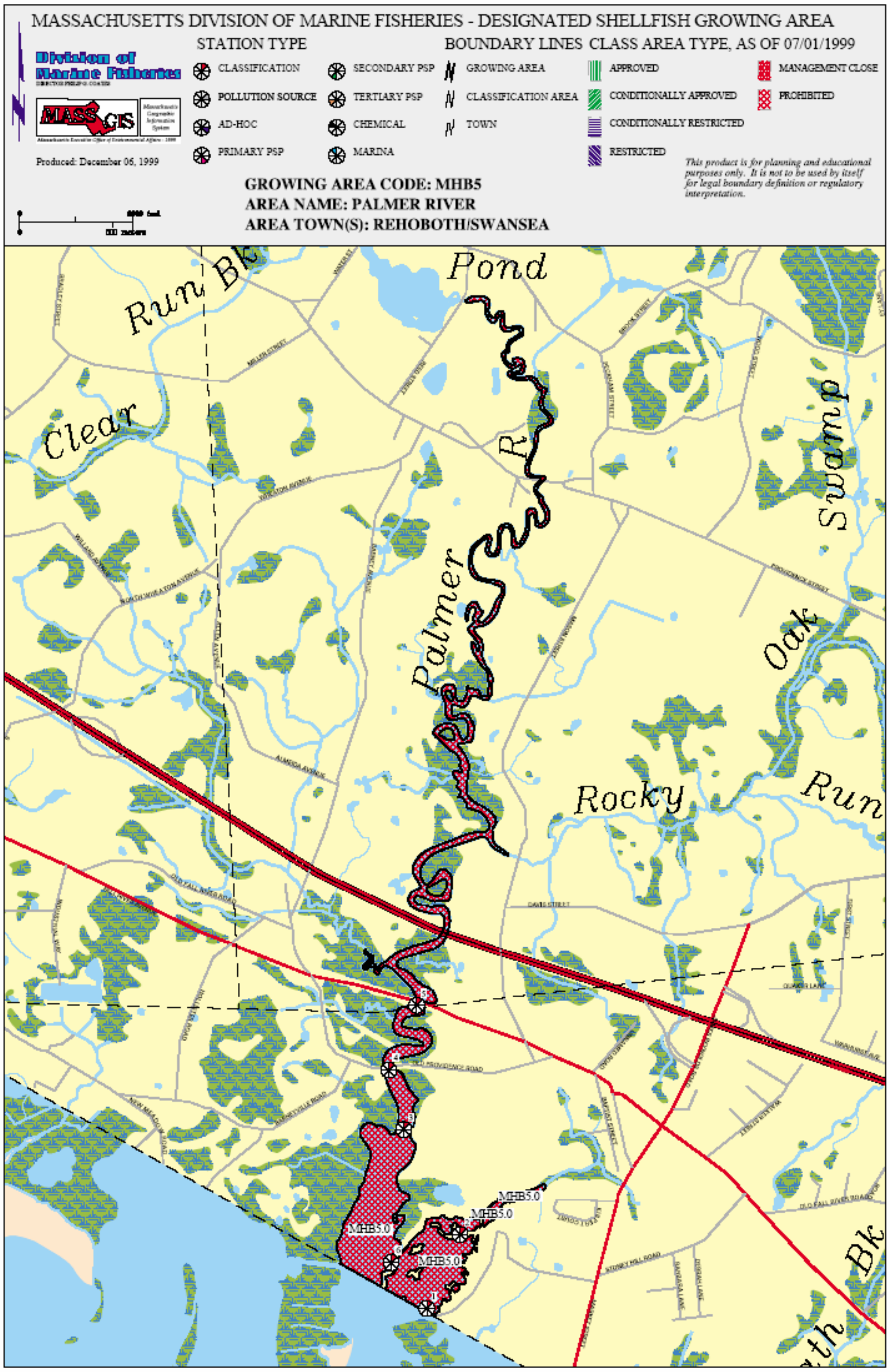
The Palmer River watershed (Figures 1 and 2) is one of the primary sub-drainage areas within the Narragansett and Mount Hope Bays watershed. The Palmer River converges with the Barrington River in the towns of Warren and Barrington, Rhode Island to form the Warren River, which is a tributary estuary to upper Narragansett Bay.

The Palmer River watershed falls primarily within the municipalities of Rehoboth and Swansea, Massachusetts (see Figures 2 through 4). The Massachusetts portion of the watershed is 30,620 acres in area. The predominant land use in the watershed is forested land (60.3%), followed by residential development (17.0%) and agriculture (12.4%). Agricultural land uses in the Palmer River watershed are concentrated in the riparian zone of the Palmer River and its tributaries. The river is divided into two main branches – the West Branch, which is comprised of Bliss Brook and Mine Brook, and the East Branch. The "headwaters" of the Palmer River in the West Branch begin at an unnamed pond along Oak Hill Avenue in Attleboro and north of Tremont Street in Rehoboth and converge with the East Branch near Route 44 in the central part of Rehoboth. The East Branch begins at Stevens Corner in Northeast Rehoboth, west of Route 118, in a small, unnamed tributary, which eventually drains into Little Cedar Swamp. The main stem of the Palmer River flows from where the West and East Branches converge through Shad Factory Pond, into Swansea and then crosses the Rhode Island boundary into the Warren River and Narragansett Bay.

The Palmer River is recognized as an important resource for agricultural land uses and aesthetic values to the predominantly residential community in Rehoboth. The River provides recreational opportunities, plays a role in flood retention, and is a receiving water for a majority of the stormwater and overland runoff. The MDMF has designated shellfish beds up to the Shad Factory Pond dam (see map below), the extent of tidal influence in the watershed, and there are designated shellfish beds in the downstream Rhode Island waters. Although the Massachusetts beds are classified as Prohibited, the water quality goal is to meet the highest designated use(s), which in this case is harvesting shellfish.

Agriculture and residential land uses play a major role in the amount of nonpoint source pollution that goes to the River. Throughout the watershed, these two land uses account for 29.4% of the total land use. However, certain sub-basins of the Palmer River have comparatively higher agriculture and residential percentages, resulting in larger NPS contributions. NPS impacts are typically exacerbated in areas where vegetated buffers have been removed or destroyed because of adjacent land uses.

In the Palmer River, nonpoint sources of pollution originate predominantly from agricultural land uses adjacent to the Palmer River and its tributaries; residential areas with problem septic systems; stormwater and sediment runoff from highway, residential, agricultural and commercial land uses; and areas where geese feed and congregate such as golf courses. The transmission of stormwater and sediment is controlled only through sheet or "country" drainage or traditional catch basins in most areas of the watershed, and the location of stormwater outfalls to the surface waters is generally undocumented. Vegetated buffers are narrow or non-existent in many areas throughout the watershed, particularly in areas where farm animals are kept.


MASSACHUSETTS DIVISION OF MARINE FISHERIES - DESIGNATED SHELLFISH GROWING AREA
Division of Marine Fisheries
MASS GIS
Produced: December 06, 1999
STATION TYPE
CLASSIFICATION
POLLUTION SOURCE
AD-HOC
PRIMARY PSP
SECONDARY PSP
TERTIARY PSP
CHEMICAL
MARINA
BOUNDARY LINES
GROWING AREA
CLASSIFICATION AREA
TOWN
CLASS AREA TYPE, AS OF 07/01/1999
APPROVED
CONDITIONALLY APPROVED
CONDITIONALLY RESTRICTED
RESTRICTED
MANAGEMENT CLOSE
PROHIBITED
This product is for planning and educational purposes only. It is not to be used by itself for legal boundary definition or regulatory interpretation.
GROWING AREA CODE: MHB5
AREA NAME: PALMER RIVER
AREA TOWN(S): REHOBOTH/SWANSEA
Pond
Run Bk
Clear
Palmer
R
Swamp
Oak
Rocky
Run
Bk
MHB5.0
MHB5.0
MHB5.0
MHB5.0

2.0 PROBLEM ASSESSMENT

Fecal coliform bacteria are found in the intestinal tract of warm-blooded animals and measurement of their concentration in surface waters is used as an indicator of pathogen contamination. Previous studies indicated that bacterial loading in the Palmer River was greater than that observed in other rivers within the Narragansett Watershed (RIDEM, 1999) and, therefore, has the potential to disproportionately impact downstream water and habitat quality. In 1998, the Palmer River was placed on the State of Rhode Island's 303(d) List of Impaired Waters for pathogens (RIDEM, 1998). Because the river had historically been used as a shellfish harvesting area, it was listed as a state priority (Group 1) waterbody, to be given the highest priority for TMDL development. The 303(d) listing was based on the results of ambient water sampling for fecal coliform, which is used by the State of Rhode Island as an indicator of pathogen contamination. RIDEM developed a bacteria TMDL for the 303(d) listed Rhode Island segments of Palmer River. RIDEM maintains that fecal coliform sources in Massachusetts are the predominant contributors to the high bacterial concentrations downstream in the main body of the Palmer River (RIDEM, 2002). However, several substantial bacteria sources were identified in Rhode Island which influence water quality in the Palmer River, including the Blount Seafoods facility and densely developed areas with large pet waste accumulations in the Town of Warren (RIDEM, 2002).

Additionally, previous studies have documented elevated pathogen (e.g., bacteria) and/or nutrient levels along specific segments of the Palmer River (MA53-03, from the Route 6 bridge in Rehoboth to the State Line; MA53-04, from the confluence of the East and West Branches of the Palmer River to the Shad Factory Pond dam, Rehoboth; and MA53-05, from Shad Factory Pond dam to Route 6 bridge, Rehoboth), resulting in placement of these segments on the *Massachusetts Year 2002 Integrated List of Integrated Waters*. For these listed segments of the Palmer River, MADEP considers the term pathogens to mean fecal coliform bacteria since that is the parameter represented in the state water quality standard.

Upstream sources of fecal coliform bacteria, *E. coli* bacteria, and nutrients - specifically those sources located along the mainstem of the Palmer River and its associated tributaries in Massachusetts - were targeted for sampling and characterization. The results of the Palmer bacterial and nutrient assessments can be found in the *Nonpoint Source Management Plan* for the Ten Mile River/Narragansett and Mt. Hope Bays Watershed NPS Assessment Project (ESS, 2003A). These results are summarized in Section 4.0 below.

Data used in the development of this TMDL were collected according to an approved Quality Assurance Project Plan (QAPP). Data collected by ESS in 2001 and 2002, RIDEM in 1996-2002, MADEP 1999, and MDMF in 1997 indicate localized exceedences of the Massachusetts fecal coliform standard. This TMDL report addresses fecal coliform contamination originating within the Palmer River watershed. It addresses the entire length of the river from the headwaters to the Rhode Island border as well as all tributaries to the Palmer River in Massachusetts. The locations of the sample stations included in this study are included in the tables in Appendix A. This report does not address other pollutants identified on the 303(d) list that may be contributing to the non-attainment of water quality standards.

3.0 WATER QUALITY STANDARDS

Evaluation of water quality results was based on standards defined in the Massachusetts Surface Water Quality Standards for Class B and SA water bodies and Aquatic Life Use (314 CMR 4.00), which indicate conditions that would be beneficial for the establishment and maintenance of native, naturally diverse communities of aquatic flora and fauna. The Palmer River and its tributaries, from headwaters to the outlet of Shad Factory Pond, are classified as Class B waters (314 CMR 4.06).

The MDMF has designated shellfish beds up to the Shad Factory Pond dam (downstream of Site PM08), the extent of tidal influence in the watershed, and there are designated shellfish beds in the downstream Rhode Island waters. Although the Massachusetts beds are classified as Prohibited, the water quality goal is to meet the highest designated use(s), which in this case is harvesting shellfish. Therefore, in the section of the Palmer River below the Shad Factory Dam, waters are Class SA and the fecal coliform standard is a geometric mean of 14cfu/100 ml and no more than 10% shall exceed 43cfu/100 ml (MADEP, 2004).

For Class B waters, the water quality standards require that fecal coliform bacteria concentrations shall not exceed a geometric mean of 200 organisms per 100 ml (a.k.a., org/100 ml or col/100 ml) in any representative set of samples, nor shall more than 10 percent of the samples exceed 400 organisms per 100 ml. Massachusetts State Water Quality Standards include the following definition of Class B waters and numeric fecal coliform concentration targets:

> **Class B:** "These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value."
>
> **Fecal Coliform Bacteria:** "Shall not exceed a geometric mean of 200 organisms per 100 ml in any representative set of samples nor shall more than 10% of the samples exceed 400 organisms per 100 ml. This criterion may be applied on a seasonal basis at the discretion of the Division."
>
> **Class SA:** "These waters are designated as an excellent habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting without depuration (Open Shellfish Areas). These waters shall have excellent aesthetic value."

Fecal Coliform Bacteria: "Waters approved for open shell-fishing [sic] shall not exceed a geometric mean MPN of 14 organisms per 100 ml, nor shall more than 10% of the samples exceed a MPN of 43 per 100 ml (more stringent regulations may apply, see 314 CMR 4.06(1)(d)(4); and waters not designated for shellfishing shall not exceed a geometric mean of 200 organisms in any representative set of samples, not shall more than 10% of the samples exceed 400 organisms per 100 ml. This criterion may apply on a seasonal basis at the discretion of the Department."

The ESS (2003A) assessment considered sites in Class B waters with dry- or wet-weather fecal coliform levels found to exceed 200 colonies/100mL to be "impaired" (i.e., not supporting designated use(s)). Sites in Class SA waters with dry- or wet-weather fecal coliform levels found to exceed 14 colonies/100mL were also considered "impaired."

4.0 FECAL CONTAMINATION OF THE PALMER RIVER BASIN

This section provides an inventory and analysis of instream fecal coliform monitoring data for the Palmer River watershed collected within the past five years in accordance with an approved QAPP.

4.1 Inventory and Analysis of Instream Fecal Coliform Data

Numerous efforts to monitor and assess water quality and identify and address potential sources of nonpoint source pollution in the study area have been conducted over the years by non-profit watershed associations, regional planning associations, the Commonwealth of Massachusetts, RIDEM, and others. Much of this data was collected for specific purposes related to the immediate goals of the organization involved (e.g., shellfish bed management and environmental education). While all of the data collected as part of these studies was reviewed as part of ESS' (2003A) nonpoint source assessment, only some of this data was determined to be applicable to the primary goal at hand: to identify significant sources of nonpoint source pollution, prioritize these sources, and develop a management plan to protect and improve water quality in the study watersheds. Therefore, a work program including water quality monitoring and modeling, field reconnaissance, consultations with municipal officials and others with knowledge of the watersheds, historical data research, data mapping, and local capacity assessment was developed to provide a comprehensive assessment of water quality issues related to bacterial and nutrient pollution in the study area. The bacteria concentration data collected as part of that effort - in addition to MADEP, MDMF, and RIDEM data collected in the past five years - are the primary data source considered in this Palmer River Bacteria TMDL Report.

4.1.1 Bacteria Data Sources and Results Summary

MADEP Data

MADEP and its predecessor, the Department of Environmental Quality Engineering (DEQE), have monitored water quality in portions of the study area since 1968. MADEP (1999) found relatively high bacteria (fecal coliform and *E. coli*) concentrations at sites RR05, PM06, RR06, PE04, and PM10 in samples collected in June through August 1999 (see Appendix B). The results of these studies identified a variety of water quality problems in the Palmer River, primarily associated with nonpoint source pollution (the Palmer River has no documented point sources).

MDMF Data

The Massachusetts Division of Marine Fisheries (MDMF) has also monitored water quality in tidal portions of the study area since the mid-1990s as part of sanitary surveys related to shellfish bed management. The MDMF (1997) found relatively high bacteria (fecal coliform) concentrations on Rocky Run at sites at site RR06 (Mason Street), and the Palmer mainstem at sites PM10 (Providence Street), site PM11 (Old Providence Street Bridge) as well as PS2, PS3, PS9, PS4, PS8, PS10, and PS11 (locations not available) in dry-weather samples collected in August 1997 (see Appendix B).

RIDEM Data

RIDEM (2002) found relatively high bacterial concentrations in portions of Rocky Run between Davis Street and Mason Street in addition to downstream areas in Rhode Island waters (see Appendix B). The highest bacterial concentrations observed by RIDEM in the upper Palmer River watershed during wet-weather were associated with runoff from adjacent cropland, pasture, and dairy farms. According to RIDEM, fecal matter from domestic animals, wildlife, waterfowl, and failing septic systems may also be washed off forested areas, lawns, golf courses, and roadways into the Palmer River during rain events. RIDEM considers its station 6A, located in the upper portion of the mainstem of the Palmer River (just south of the State Line) to represent Massachusetts' sources to the Rhode Island portion of the Palmer River in both dry- and wet-weather (RIDEM, 2002).

ESS 2001 and 2002 Monitoring and Modeling Results

From early spring to winter 2001, Rounds I and II of the ESS sampling effort were conducted. ESS sampled bacteria at a total of 76 locations (Appendix A) in both dry- and wet-weather conditions in the Palmer River watershed. These sites include 11 mainstem sites, 32 initial tributary sites, and 33 additional tributary sites (selected based on results of mainstem and initial tributary sampling as well as land use and field observations). In addition to bacteria sampling, 10 sites in the Palmer were sampled for a selected suite of nutrient parameters and a subset of these sites were sampled for diurnal DO, temperature (using continuous recording gauges), aquatic vegetation, and Chlorophyll *a* (ESS, 2003A).

Round III sampling, which was conducted in late 2001 and early 2002, included wet- and dry-weather sampling efforts covering 24 sites in order to bracket potential sources of bacterial pollution which were identified during previous sample rounds and other data gathering efforts conducted as part of the Project. The rationale for selecting Round III sites is presented in Appendix 7 of the ESS (2003A) NPS assessment. Round III results are presented in Appendix B.

Based on the results of laboratory analysis of bacteria samples collected by ESS during sampling Rounds I and II (early spring to winter 2001), the following preliminary findings were reported:

- Extremely high fecal coliform concentrations (>1,000 col./100 ml, sometimes >10,000 col./100 ml) were found at sites on Bad Luck Brook (BL-01), Fullers Brook (FB-02 and FB-03), Clear Run Brook (CR-01), Beaverdam Brook (BB-01), Rocky Run (RR-05), and Torrey Creek (TC-01).
- Lesser exceedences of fecal coliform standards (>200 col./100 ml) were found at Bliss Brook (BA-01, BA-02, and BA-03), Clear Run Brook (CR-02, CR-03), Oak Swamp Brook (OS-01), Palmer East Branch (PE-03, PE-05, and PE-05), Palmer Mainstem (PM-05, PM-07, PM-10, PM-12, PM-14, PM-16B, PM-17, PM-18) Palmer West Branch (PW-01, PW-05), Rumney Marsh Brook (RB-01 and RB-02), Rocky Run (RR-02, RR-03, RR-04, RR-06, RR-07, and RR-12), Torrey Creek (TC-03, TC-04, TC-05, TC-06, TC-07, TC-08), Beaverdam Brook (BB-02), Clear Run Brook (CR-05).

Overall, ESS found that water quality at 18 of 88 sample sites exceeded the Massachusetts primary contact (e.g., swimming) standard for fecal coliform, and at least 32 sites had at least one relatively high bacteria count. No sites failed the federal *E. coli* standard in part because either fewer than three samples were conducted or samples were not collected within 60 days of one another. In general, the results for *E. coli* were similar to those for fecal coliform.

The "worst" sub-basins with regard to wet-weather bacteria results were Fullers Brook (part of the Palmer Mainstem/PM08 sub-basin), Bad Luck Brook (part of the Palmer East Branch/PE06 sub-basin), Torrey Creek, Rocky Run, and Clear Run Brook. The highest bacteria counts were found at sites FB02, FB03, BL01, TC01, RR05, and CR01. With regard to dry-weather results, FB02 and TC07 were found to have the highest single event concentrations (220,000 and 1,000 col./100 ml, respectively).

In addition, a Screening Model was applied to the Palmer River watershed by Applied Science Associates, Inc. (ASA) as part of the ESS (2003A) nonpoint source assessment. The model predicted the highest relative instream fecal coliform concentrations by sub-basin. The Screening Model predicted the highest relative instream fecal coliform concentrations in sub-basins CR03, TC03, RR06, PM08, and PE06 (see Appendix 8 of ESS, 2003A). These sub-basins are consistent with those found to have the highest bacteria concentrations based on ESS monitoring results.

ESS 2002 DNA Ribotyping Results

The Palmer River Microbial Source Tracking (MST) study (ESS, 2003B) was conducted as part of the Ten Mile River/Narragansett and Mount Hope Bays Nonpoint Source (NPS) Assessment, by ESS during 2001 and 2002. The MST study focused on a select set of Palmer River watershed sub-basins in November 2002. Based on the findings of the NPS assessment, six (6) locations were selected for "DNA ribotyping". DNA ribotyping of *E.coli* isolates is one of several accepted approaches to identifying sources of fecal-borne contamination. This approach enables the differentiation of bacteria sources by animal species (e.g., horse, pig, cow, human).

Sites were selected to undergo DNA ribotyping based on the following criteria:

- Sites with extremely high bacteria concentrations during previous sample rounds.
- Sites in sub-basins with multiple potential bacteria sources that could not be differentiated based on field reconnaissance alone.
- Multiple potential human and animal sources.
- Multiple potential agricultural sources or other suspected sources.
- Sites at or near the outlet of the Palmer River watershed to characterize waters leaving Massachusetts and entering Rhode Island (i.e., site PM25).

Based on the above criteria, ESS, EOEA, and DEP selected the following six (6) sites, out of the 100 sample sites from the NPS assessment, for further assessment using DNA ribotyping:

- CR03 – Clear Run Brook (Rehoboth, MA)
- FB02 – Fullers Brook (Rehoboth, MA)
- BL01 – Bad Luck Brook (Rehoboth, MA)
- PM25 – Palmer River (Main Stem) (Swansea, MA)
- TC01 – Torrey Creek (Rehoboth, MA)
- RR06 – Rocky Run (Rehoboth, MA)

FB02 was the only site where samples were collected under wet and dry weather conditions, yielding a direct comparison for both conditions. CR03 was sampled under dry-weather conditions only. BL01, PM25, TC01, and RR06 were sampled under wet-weather conditions only. FB02 is the site with the highest *E. coli* concentrations of all sites sampled.

Tables 1 through 5 in Appendix C summarize the results of DNA ribotyping. Horses were relatively more significant (and as significant as pigs), during dry weather, while cows made up a large fraction (40%) of the isolates during wet weather. At most of the six (6) study sites, all the identified isolates were established to have come from animal scat, predominantly cows and pigs, but also dogs, deer, horses, and rabbits. Only two (2) sites were found to contain isolates of human fecal waste, and only 10% of the identified isolates from those sites were found to be human. At site FB02, during wet weather conditions, half of the identified isolates were established as coming from local cows, which indicates cows are likely to be a substantial source of NPS pollution at this site. These findings point strongly toward agriculture as the primary source of bacterial pollution in the sub-basins evaluated.

4.2 Analysis of Overall Instream Bacteria Dataset

This section presents an analysis of fecal coliform data collected within the Palmer River basin between 1997 and 2002. A total of 262 water quality samples (104 wet-weather and 158 dry-weather) which were analyzed for fecal coliform concentration collected within the Palmer River basin during this period were used to develop the TMDL discussed below. Data collected by ESS, MADEP, MDMF, and RIDEM are compared to the State Water Quality Standards in this assessment to determine exceedances of standards occurring within the watershed.

4.2.1 Defining Wet and Dry Weather Samples

A rain gage located at T.F. Green Airport in Cranston, Rhode Island was used to identify wet and dry weather data conditions. This is the closest monitoring station to the study area with long term meteorological data. Over the 1997 to 2002 period, approximately 60% of the samples were dry weather samples, while approximately 40% were wet weather samples. Where available, dry and wet weather samples were compared separately.

For the purposes of this TMDL, dry and wet weather samples are defined as:

- Dry weather sample: any sample collected on a day where no significant precipitation (<0.1 inch) was recorded in the previous 72 hours.
- Wet weather sample: any sample collected on a day where the early stages of a storm event (i.e., as close to first flush as possible) were greater than 0.25 inches in magnitude and that occurred at least 72 hours since the previously measurable storm event.

Table 1 presents total precipitation for the years during which monitoring occurred, and a comparison to the average precipitation for the T.F. Green gauging station. As shown in this table, 2000 was the closest to an average year of the years during which monitoring occurred in terms of precipitation totals, while 1996 and 1998 were wetter than average and 1997, 2001, and 2002 were drier than average years.

Table 1. Precipitation Analysis

Year	Total precipitation (in)	% difference from average[1]	Monitoring conducted
1996	48.06	+6%	Dry weather only
1997	37.97	-17%	Dry weather only
1998	52.70	+16%	None
1999	42.26	-6%	Dry weather only
2000	46.00	+1%	None
2001	40.19	-12%	Wet and dry weather
2002	42.34	-7%	Wet and dry weather

[1]Average total precipitation = 45.53 inches

4.2.2 Data Analysis

Table 2 and the tables in Appendix B present the geometric means and percent of samples exceeding 400 organisms per 100 ml for each location for Class B waters. For those Palmer River sample locations downstream of Shad Factory Pond dam (Class SA waters), Table 2 presents the geometric means and percent of samples exceeding 14 organisms per 100 ml for each location. Geometric means were calculated using all applicable data collected by ESS, MADEP, MDMF, and/or RIDEM from 1997 to 2002. An analysis of all validated data collected by ESS, MADEP, MDMF, and RIDEM between 1997 and 2002 is presented in Table 2. Consistent with the Water Quality Standards for fecal coliform, data are summarized and presented in terms of a geometric mean and also in terms of percent of samples that exceed the 14 and 43 (Class SA), or the 200 and 400 (Class B) organisms/100 ml standards. In instances where both wet and dry weather samples were collected, geometric means are presented for both conditions as well as for the entire data set.

The MDMF has designated shellfish beds up to the Shad Factory Pond dam (upstream of Site PM08), the extent of tidal influence in the watershed, and there are designated shellfish beds in the downstream Rhode Island waters. Although the Massachusetts beds are classified as Prohibited, the water quality goal is to meet the highest designated use(s), which in this case is harvesting shellfish. Therefore, in the section of the Palmer River below the Shad Factory Dam, waters are Class SA and the fecal coliform standard is a geometric mean of 14cfu/100 ml and no more than 10% shall exceed 43cfu/100 ml (MADEP, 2004). It should also be noted that the water quality goal set in the Rhode Island bacteria TMDL (RIDEM, 2002) at the state line was the Class SA standard, 14 cfu/100 ml with a 90th percentile of 49 cfu/100 ml.

Review of these data indicates violations of the Massachusetts bacteria standard occur regularly during wet and dry weather in the two Palmer River mainstem segments listed for pathogens on the 303(d) list as well as numerous other water body segments in the basin. These 303(d) listed segments have violated water quality standards during the period reviewed for at least one sample location:

- MA53-03, from the Route 6 bridge in Rehoboth to the State Line;
- MA53-04, from the confluence of the East and West Branches of the Palmer River to the Shad Factory Pond dam, Rehoboth; and
- MA53-05, from Shad Factory Pond dam to Route 6 bridge, Rehoboth).

Sample stations within segment MA53-03 at which violations of the Massachusetts bacteria standard were observed include PM25 (Palmer Mainstem – unnamed salt marsh creek in Swansea). Sample stations within segment MA53-05 at which violations of the Massachusetts bacteria standard were observed include PM08 (Palmer Mainstem – outlet of Shad Factory Pond), PM14 (Palmer Mainstem – tributary below Shad Factory Pond), PM26 (Palmer Mainstem in Rehoboth), PM10 (Palmer Mainstem in Rehoboth), and PM11 (Palmer Mainstem – Bungtown Bridge in Swansea). No violations of the Massachusetts bacteria standard were observed in segment MA53-04. However, numerous violations were observed in tributaries to this segment (see Table 2).

This TMDL applies not only to those segments within the Palmer River basin that appear on the *Massachusetts Year 2002 Integrated List of Waters* (MADEP, 2002) for pathogen violations, but also to all segments in this basin that are identified as being impaired by pathogens through the evaluation of water quality monitoring data as presented in this report. Other water body segments in the Palmer River watershed in which violations of the Massachusetts bacteria standard were observed include:

- Palmer River-West Branch (PW01, PW05, BA01, BA02, and BA03),
- Palmer River-East Branch (PE04, PE06, and PE09),
- Rumney Marsh Brook (RB01 and RB02),
- Beaver Dam Brook (BB01),
- Bad Luck Brook (BL01 and BL02),
- Fullers Brook (FB02, FB03, and FB04),
- Clear Run (CR01, CR02, CR03 and CR07),
- Torrey Creek (especially TC01),
- Old Swamp Brook (OS01 and OS04), and

- Rocky Run (RR05, RR06, and RR07).

In total, of the 88 Palmer River watershed sample stations included in the NPS study, water quality at 33 violated Massachusetts bacteria standards (see Table 2 and Appendix B). For Class B waters, the most severe violations of these standards occurred at FB02, FB03, CR03, TC01, RB02, CR02, and RR05 (listed in order of severity). For Class SA waters, the most severe violations of these standards occurred at PM25, PM26, PM10, PM11, and PM08.

Table 2. Analysis of All Fecal Coliform Data Collected by ESS, MADEP, MDMF and RIDEM (1997-2002) (cfu/100ml)

NOTES:
Shading indicates Massachusetts Water Quality Standards (DEP, 1996) exceeded and/or extremely high count.
[1]Geometric mean to be less than or equal to 200 organisms/100 ml (Class B)
[2]No more than 10% of the samples shall exceed 400 organisms/100 ml (Class B)
[3]Geometric mean to be less than or equal to 14 organisms/100 ml (Class SA)
[4]No more than 10% of the samples shall exceed 43 organisms/100 ml (Class SA)

Water Body (Class B)	Station	Collecting Agency/ Organization	Geometric Mean (overall wet and dry) (cfu/100 ml)	% Reduction (overall wet and dry)[1]	Dry Weather Geometric Mean (cfu/100 ml)	Wet Weather Geometric Mean (cfu/100 ml)	Wet Weather % Reduction	% of Samples > 400 cfu/100 ml[2]	90% Observation (cfu/100 ml)	% Reduction for 90% Observation[2]
Palmer River - West Branch	PW01	ESS	335	40%	170	660	70%	50%	660	39%
	PW02	ESS/DEP	44	0%	37	75	0%	0%	130	0%
	PW03	ESS	137	0%	110	170	0%	0%	170	0%
	PW04	ESS	19	0%	8	44	0%	0%	44	0%
	PW05	ESS	119	0%	19	740	73%	50%	740	46%
	PW06	ESS	3	0%	1	7	0%	0%	7	0%
	WB01	ESS	1	0%	1	No sample	NA	0%	1	0%
	BA01	ESS	55	0%	7	430	53%	50%	430	7%
	BA02	ESS	66	0%	1	8,800	98%	50%	8,800	95%
	BA03	ESS	189	0%	54	660	70%	50%	660	39%
	BA04	ESS	1	0%	1	4	0%	0%	4	0%
	BA05	ESS	18	0%	21	16	0%	0%	21	0%
	BA06	ESS	1	0%	1	1	0%	0%	1	0%
Palmer River - East Branch	PE03	ESS	186	0%	302	70	0%	0%	380	0%
	PE04	ESS	320	37%	369	240	17%	0%	390	0%
	PE05	ESS	48	0%	9	260	23%	0%	260	0%
	PE06	ESS/DEP	179	0%	125	370	46%	33%	1,300	69%
	PE07	ESS	6	0%	2	19	0%	0%	19	0%
	PE08	ESS	24	0%	10	57	0%	0%	57	0%
	PE09	ESS	390	49%	390	No sample	NA	0%	390	0%
Rumney Marsh Brook and Beaver Dam Brook	RB01	ESS	107	0%	6	1,900	89%	50%	1,900	79%
	RB02	ESS	832	76%	77	9,000	98%	50%	9,000	96%
	BB01	ESS	438	54%	16	12,000	98%	50%	12,000	97%
	BB02	ESS	76	0%	22	260	23%	0%	260	0%
Bad Luck Brook and Warren Upper Reservoir	BL01	ESS	464	57%	1	1,667	88%	67%	42,000	99%
	BL02	ESS	125	0%	33	470	57%	50%	470	15%
	BL03	ESS	150	0%	No sample	150	0%	0%	150	0%
	WR01	ESS	21	0%	21	21	0%	0%	22	0%
	WR02	ESS	No Flow	NA	No Flow	No Flow	NA	NA	No Flow	NA
	WR03	ESS	6	0%	12	3	0%	0%	12	0%
Fullers Brook	FB01	ESS	56	0%	56	No sample	NA	0%	56	0%
	FB02	ESS	85,337	100%	36,641	95,917	100%	100%	220,000	100%
	FB03	ESS	40,000	100%	310	22,000	99%	50%	22,000	98%
	FB04	ESS	64	0%	10	415	52%	50%	500	20%
Clear Run Brook	CR01	ESS	512	61%	12	3,341	94%	67%	18,000	98%
	CR02	ESS	759	74%	282	2,040	90%	50%	3,200	88%
	CR03	ESS/DEP	1,186	83%	455	13,000	98%	50%	13,000	97%

Table 2. Analysis of All Fecal Coliform Data Collected by ESS, MADEP, MDMF and RIDEM (1997-2002)(cfu/100ml)

NOTES:
Shading indicates Massachusetts Water Quality Standards (DEP, 1998) exceeded and/or extremely high count.
[1]Geometric mean to be less than or equal to 200 organisms/100 ml (Class B)
[2]No more than 10% of the samples shall exceed 400 organisms/100 ml (Class B)
[3]Geometric mean to be less than or equal to 14 organisms/100 ml (Class SA)
[4]No more than 10% of the samples shall exceed 43 organisms/100 ml (Class SA)

Water Body (Class B)	Station	Collecting Agency/ Organization	Geometric Mean (overall wet and dry) (cfu/100 ml)	% Reduction (overall wet and dry)[1]	Dry Weather Geometric Mean (cfu/100 ml)	Wet Weather Geometric Mean (cfu/100 ml)	Wet Weather % Reduction	% of Samples > 400 cfu/100 ml[2]	90% Observation (cfu/100 ml)	% Reduction for 90% Observation[2]
Clear Run Brook	CR04	ESS	95	0%	57	160	0%	0%	160	0%
	CR05	ESS	65	0%	19	120	0%	0%	270	0%
	CR06	ESS	72	0%	76	68	0%	0%	76	0%
	CR07	ESS	320	38%	320	No sample	NA	0%	320	0%
Palmer River-Main Stem	PM05	ESS	92	0%	61	210	5%	0%	210	0%
(Upstream of Shad Factory Pond Outlet)	PM06	ESS	79	0%	59	140	0%	0%	140	0%
	PM07	ESS	136	0%	87	330	39%	0%	330	0%
	PM12	ESS	85	0%	47	280	29%	0%	280	0%
	PM16	ESS	66	0%	17	260	23%	0%	260	0%
	PM17	ESS	49	0%	12	200	0%	0%	200	0%
	PM18	ESS	164	0%	73	370	46%	0%	370	0%
	PM19	ESS	83	0%	37	185	0%	0%	210	0%
	PM20	ESS	65	0%	30	140	0%	0%	160	0%
	PM21	ESS	47	0%	25	87	0%	0%	87	0%
	PM24	ESS	No Flow	NA	No Flow	No Flow	NA	NA	No Flow	NA
Torrey Creek	TC01	ESS	317	37%	70	524	62%	67%	24,000	98%
	TC02	ESS	10	0%	10	No sample	NA	0%	10	0%
	TC03	ESS	296	33%	84	1,050	81%	25%	3,800	89%
	TC04	ESS	99	0%	200	49	0%	0%	200	0%
	TC05	ESS	257	22%	110	1,100	82%	33%	1,100	64%
	TC06	ESS	100	0%	36	280	29%	0%	280	0%
	TC07	ESS	263	24%	263	No sample	NA	50%	1,000	60%
	TCO8	ESS	89	0%	200	40	0%	0%	200	0%
	TC09	ESS	10	0%	10	No sample	NA	0%	10	0%
	TC10	ESS	200	0%	No sample	200	0%	0%	200	0%
	TC11	ESS	273	27%	340	220	9%	0%	340	0%
	TC12	ESS	138	0%	100	190	0%	0%	190	0%
	TC13	ESS	3	0%	1	11	0%	0%	11	0%
Oak Swamp Brook	OS01	ESS	542	63%	140	2,100	90%	50%	2,100	81%
	OS03	ESS	41	0%	42	40	0%	0%	42	0%
	OS04	ESS	140	0%	15	1,300	85%	50%	13,000	97%
Rocky Run	RR01	ESS	35	0%	20	60	0%	0%	60	0%
	RR02	ESS	144	0%	80	260	23%	0%	260	0%
	RR04	ESS	90	0%	28	290	31%	0%	290	0%
	RR05	ESS/RIDEM	552	64%	366	5,254	96%	69%	1,280	69%
	RR06	ESS/RIDEM/ DEP/DMF	422	53%	331	822	76%	50%	0	0%
	RR07	ESS	23	0%	1	520	62%	50%	520	23%

Table 2. Analysis of All Fecal Coliform Data Collected by ESS, MADEP, MDMF and RIDEM (1997-2002) (cfu/100ml)

NOTES:
Shading indicates Massachusetts Water Quality Standards (DEP, 1998) exceeded and/or extremely high count.
[1]Geometric mean to be less than or equal to 200 organisms/100 ml (Class B)
[2]No more than 10% of the samples shall exceed 400 organisms/100 ml (Class B)
[3]Geometric mean to be less than or equal to 14 organisms/100 ml (Class SA)
[4]No more than 10% of the samples shall exceed 43 organisms/100 ml (Class SA)

Water Body (Class B)	Station	Collecting Agency/ Organization	Geometric Mean (overall wet and dry) (cfu/100 ml)	% Reduction (overall wet and dry)[1]	Dry Weather Geometric Mean (cfu/100 ml)	Wet Weather Geometric Mean (cfu/100 ml)	Wet Weather % Reduction	% of Samples > 400 cfu/100 ml[2]	90% Observation (cfu/100 ml)	% Reduction for 90% Observation[2]
Rocky Run	RR08	ESS	11	0%	1	130	0%	0%	130	0%
	RR10	ESS	11	0%	33	4	0%	0%	33	0%
	RR11	ESS	15	0%	74	3	0%	0%	74	0%
	RR12	ESS	179	0%	140	230	13%	0%	230	0%
	RR13	ESS	130	0%	130	No sample	NA	0%	130	0%
Palmer - Tributary to Mainstem	PM14	ESS	96	0%	63	142	0%	25%	3,100	87%
(Downstream of the Shad Factory Pond Outlet)	PM22	ESS	11	0%	56	2	0%	0%	56	0%
	PM23	ESS	25	0%	26	24	0%	0%	30	0%
Water Body (Class SA)	**Station**	**Collecting Agency/ Organization**	**Geometric Mean (overall wet and dry) (cfu/100 ml)**	**% Reduction (overall wet and dry)[3]**	**Dry Weather Geometric Mean (cfu/100 ml)**	**Wet Weather Geometric Mean (cfu/100 ml)**	**Wet Weather % Reduction**	**% of Samples > 43 cfu/100 ml[4]**	**90% Observation (cfu/100 ml)**	**% Reduction for 90% Observation[4]**
Palmer River - Main Stem	PM08	ESS/RIDEM/ DEP/DMF	173	92%	195	155	91%	91%	957	96%
(Downstream of the Shad Factory Pond Outlet)	PM26	ESS	230	94%	230	No sample	NA	100%	230	81%
	PM10	ESS/DMF	188	93%	140	315	96%	100%	450	90%
	PM11	ESS/DEP/DMF	180	92%	126	444	97%	71%	1,600	97%
	PM25	ESS	278	95%	145	406	97%	100%	1,100	96%

5.0 IDENTIFICATION OF FECAL COLIFORM BACTERIA SOURCES

All known potential sources of fecal coliform bacteria in the Palmer River watershed were examined using all available and applicable information. Direct concentration measurements were unavailable for many bacteria sources. However, through the evaluation of water quality monitoring data, interviews with local officials and watershed stewards, and analysis of land uses within the watershed and literature values for typical stormwater concentrations, it was possible to identify likely bacteria sources. This TMDL applies not only to those segments within the Palmer River basin that appear on the *Massachusetts Year 2002 List of Integrated Waters* (MADEP, 2002) for pathogen violations, but also to all segments in this basin that are identified as being impaired by pathogens through the evaluation of water quality monitoring data as presented in this report (see Section 4.2.2).

Summary Table B in Appendix B summarizes the river segments that are impaired due to measured fecal coliform contamination and identifies suspected and known sources to these segments and their tributaries, as identified by ESS (2003A). This table also includes both segments on the *Massachusetts Year 2002 List of Integrated Waters* (MADEP, 2002) and non-listed but impaired segments.

Several sub-basins in the Palmer River watershed stand out as likely priority areas to address bacteria pollution sources. These sub-basins tend to be located in the southern and western portions of the watershed, where relatively dense residential development is increasing, major roads and highways are present, intensive agriculture is practiced, golf courses and the waterfowl that frequent them are plentiful, and stream channels are less buffered by forested and otherwise vegetated zones than they are in the upper Palmer. Based on the findings of the ESS (2003A) NPS Assessment and the Microbial Source Tracking (MST) Study (ESS, 2003B), the following sub-basins should be focused on for future nonpoint source abatement efforts: Fullers Brook (FB03), Clear Run (CR03), Rocky Run (RR06), and lower Palmer River mainstem (PM11).

As discussed in Section 4.1.1 above, for the MST study sites, horses were relatively more significant dry-weather sources (and as significant as pigs), while cows made up a large fraction (40%) of the isolates during wet-weather. At most of the six (6) study sites, all the identified isolates were established to have come from animal scat, predominantly cows and pigs, but also dogs, deer, horses, and rabbits. At site FB02, during wet-weather conditions, half of the identified isolates were established as coming from local cows, which indicates cows are likely to be a substantial source of NPS pollution at this site. These findings point strongly toward agriculture as the primary source of bacterial pollution in the sub-basins evaluated using MST. Tables 1 through 5 in Appendix C summarize the results of DNA ribotyping.

Violations of the bacteria water quality standard occur during both dry- and wet-weather in the Palmer River watershed. Therefore, the discussion that follows addresses both dry-weather and wet-weather bacteria sources, as identified in Summary Table B in Appendix B and ESS (2003A).

5.1 Potential Dry Weather Sources

Dry weather source categories evaluated include poorly performing septic systems, direct wildlife, and livestock. The Palmer River watershed is not sewered, so issues related to point sources, broken sewer lines, and illicit disposal to storm drains typically found in more urbanized watersheds do not apply here.

5.1.1 Poorly Performing Septic Systems

Properly sited and maintained septic systems designed, installed and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. However, failing septic systems – due to inadequate soils, poor design, siting, testing or inspection, hydraulic overloading, tree growth in the drain field, old age, and failure to clean out – have been shown to deliver bacteria to surface waters (Center for Watershed Protection, 1999). Typical values for fecal coliform in untreated domestic wastewater range from 10^6 to 10^7 MPN/100 ml (Metcalf and Eddy, 1991).

No information was available on the specific locations of septic systems, septic tank densities, or failure rates in the Palmer River watershed. However, ESS surveyed each of the towns in the watershed to identify areas with greatest potential to contain failing septic systems due to poorly drained soils, high groundwater, or other factors. These areas are mapped on Figure 4.

5.1.2 Direct Wildfowl

Animals that are not pets can be a potential source of fecal coliforms. Geese, gulls, and ducks are speculated to be a major bacterial source, particularly at lakes and stormwater ponds where large resident populations have become established (Center for Watershed Protection, 1999). Wildfowl are of particular concern in the following subwatersheds: Torrey Creek, Clear Run Brook, Fuller Brook, Bad Luck Brook, and the lower Palmer River. Many areas of suspected or observed wildfowl concentration in the Palmer River watershed were identified by local officials and watershed stewards. These areas are mapped on Figure 4.

5.1.3 Livestock

Several sub-basins in the Palmer River watershed were more strongly influenced by agricultural inputs (primarily cows, pigs, and horses), based on findings of water quality monitoring, field reconnaissance, and DNA ribotyping. These sub-basins include: Fullers Brook, Torrey Creek, and Rocky Run.

5.2 Potential Wet Weather Sources

Potential sources for wet-weather violations of fecal coliform standards were identified from an analysis of land use patterns, interviews with local officials, DNA ribotyping (ESS, 2003B), and literature review. Stormwater runoff, including agricultural runoff, was the primary wet-weather source category evaluated. (There are no point sources such as sewage treatment plant or industrial discharges in this watershed.)

Based on findings of water quality monitoring, field reconnaissance, and DNA ribotyping, high stormwater runoff loads of bacteria are more likely to be caused by bacteria from livestock rather than from domestic animals and wildlife.

5.2.1 Stormwater Runoff

The concentration of bacteria in stormwater runoff can vary widely. Typical stormwater event mean concentrations derived from studies in Marquette, MI and Madison, WI are presented in Table 3. As shown in this table, event mean concentrations may vary depending on land use. Additionally, event mean concentrations may vary depending on location so it is preferable to collect site-specific stormwater data to most accurately characterize bacteria concentrations in runoff. Sources contributing to fecal coliform in stormwater runoff are discussed below.

Table 3. Concentrations (Geometric Mean Colonies/100ml) of Fecal Coliforms from Urban Source Areas

Land Use	Marquette, MI	Madison, WI
No. of storms sampled	12	9
Commercial parking lot	4,200	1,758
High traffic street	1,900	9,627
Medium traffic street	2,400	56,554
Low traffic street	280	92,061
Commercial rooftop	30	1,117
Residential rooftop	2,200	294
Residential driveway	1,900	34,294
Residential lawns	4,700	42,093

Steuer *et al.*, 1997; Bannerman *et al.*, 1993 as cited in Schueler and Holland, 2000

5.2.2 Domestic Animals

One source of bacteria in stormwater runoff is the feces from household pets such as cats and dogs, which comprise a large potential source of bacteria – as much as 23,000,000 #/gm, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. This translates to an estimated 1,000 dogs in the watershed producing 500 pounds of feces per day. Uncollected pet waste is flushed from the parks and yards where pets are walked into nearby waterways during wet-weather events.

5.2.3 Livestock

As discussed above, several sub-basins in the Palmer River watershed were more strongly influenced by agricultural inputs (primarily cows, pigs, and horses), based on findings of water quality monitoring, field reconnaissance, and DNA ribotyping. These sub-basins include: Fullers Brook, Torrey Creek, and Rocky Run (ESS, 2003A and ESS, 2003B).

5.2.4 Wildlife

As discussed in Section 5.1.2, geese, gulls, and ducks are speculated to be a major bacterial source, particularly at lakes and stormwater ponds where large resident populations have become established (Center for Watershed Protection, 1999). Wildfowl are of particular concern in the following subwatersheds: Torrey Creek, Clear Run Brook, Fuller Brook, Bad Luck Brook, and the lower Palmer River. Many areas of suspected or observed wildfowl concentration in the Palmer River watershed were identified by local officials and watershed stewards. These areas are mapped on Figure 4.

6.0 TOTAL MAXIMUM DAILY LOAD DEVELOPMENT

Total Maximum Daily Loads (TMDLs) are comprised of the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for non-point sources and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition may be expressed as:

$$\mathbf{LC = TMDL = \Sigma WLAs + \Sigma LAs + MOS} \qquad \textbf{Equation 1.}$$

The term LC represents the loading capacity, or maximum loading that can be assimilated by the receiving water while still achieving water quality standards. The overall loading capacity is subsequently allocated into the TMDL components of Waste Load Allocations (WLAs) for point sources, Load Allocations (LAs) for non-point sources, and the Margin of Safety (MOS).

As discussed in Section 7.1, this TMDL uses an alternative standards-based approach which is based on bacteria concentrations but considers the terms of Equation 1. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if Equation 1 were used.

7.0 FECAL COLIFORM TMDL

The components of the fecal coliform TMDL are discussed below.

7.1 Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass per time, toxicity, or some other appropriate measure (40 C.F.R. Section 130.2(i)). Typically, TMDLs are expressed as loads. However, several Massachusetts bacteria TMDLs approved by MADEP and USEPA [e.g., the Neponset (2000) and Shawsheen (2002) River Basin bacteria TMDLs] have expressed bacterial TMDLs in terms of concentration consistent with the Massachusetts fecal coliform standard, which is also concentration based (typically in colonies per 100 ml). Since source concentrations may not be directly added, Equation 1 does not apply in the case of a concentration-based TMDL. To ensure attainment with Massachusetts water quality standards for bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the standard.

Expressing the TMDL in terms of daily loads is difficult to interpret given that the numbers of bacteria and the magnitude of the allowable load are flow-dependent and, therefore, will vary as stream flow rates change. For example, a very high number of bacteria may be allowable if the volume of water that transports the bacteria is high too. Conversely, even a relatively low number of bacteria may exceed water quality standards if flow rates are low. For all the above reasons, it is most appropriate to set the TMDL equal to the concentration-based standard, expressed as follows:

TMDL = Fecal coliform standard = $WLA_{(p1)}$ = $LA_{(n1)}$ =$WLA_{(p2)}$ = etc. Equation 2.

Where:

$WLA_{(p1)}$ = allowable concentration for point source category (1)

$LA_{(n1)}$ = allowable concentration for nonpoint source category (1)

$WLA_{(p2)}$ = allowable concentration for point source category (2), etc.

For Class B surface waters, the fecal coliform TMDL (as based on the Massachusetts standard) includes two components: (1) the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 ml; and (2) no more than 10% of the samples shall exceed 400 organisms per 100 ml. For Class SA waters, the fecal coliform TMDL (as based on the Massachusetts standard) includes two components: (1) the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 ml; and (2) no more than 10% shall exceed 43 organisms per 100 ml.

The Palmer River and its tributaries, from headwaters to the outlet of Shad Factory Pond, are classified as Class B waters (314 CMR 4.06). The Palmer River and its tributaries downstream of the Shad Factory Pond dam (PM08), the extent of tidal influence in the watershed, are designated Class SA waters (MADEP, 2004).

The goal to attain water quality standards at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can easily be understood by the public and individuals responsible for monitoring activities. Also, the goal of attaining standards at the point of discharge minimizes human health risks associated with exposure to pathogens because it does not consider losses due to die-off and settling that are known to occur.

7.2 Wasteload Allocations and Load Allocations

As mentioned above, dry-weather source categories evaluated include poorly performing septic systems, direct wildlife, and livestock. The Palmer River watershed has no documented point sources of bacteria pollution. Stormwater runoff, including agricultural runoff, was the primary wet-weather source category evaluated.

Direct stormwater discharges of fecal coliform from storm drainage systems occur within the Palmer River basin. Rehoboth and Swansea are Phase II communities subject to the requirements of EPA's NPDES Phase II General Permit for MS4s. Piped dischargers are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the fecal coliform standard will be assigned to the portion of the stormwater that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry- and wet-weather sources for all segments within the Palmer River basin. Table 4 presents the fecal coliform bacteria WLAs and LAs for each of the source categories. The WLA and LA for stormwater discharging to the Palmer River and its tributaries are set equal to the fecal coliform standard for Class B waters.

Table 4. Fecal Coliform Wasteload Allocations (WLAs) and Load Allocations (LAs) for the Palmer River and Identified Tributary Streams

Bacteria Source Category	WLA (organisms/100ml)	LA (organisms/100ml)
Failing Septic Systems	0	0
Direct Wildlife	--	Geomean ≤ 200 10% ≤ 400 (Class B) or Geomean ≤ 14 10% ≤ 43 (Class SA)
Livestock	--	0
Stormwater Runoff	Geomean ≤ 200 10% ≤ 400	Geomean ≤ 200 10% ≤ 400 (Class B) or Geomean ≤ 14 10% ≤ 43 (Class SA)

Following is a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing source contributions are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources (e.g., failing septic systems), the goal is complete elimination (100% reduction). However, overall wet-weather bacteria load reductions can be estimated using typical stormwater bacteria concentrations, as presented in Table 4 above, and the magnitude of the wet-weather data observed in the Palmer basin. This information indicates that 1 to 2 orders of magnitude reductions in stormwater fecal coliform loadings will be necessary.

In addition, overall reductions needed to attain water quality standards can be estimated using the ambient fecal coliform data that are available for the Palmer River watershed. Using ambient concentration data provides more realistic estimates of existing conditions and the magnitude of cumulative loading to the surface waters than would using source discharge concentration data. Reductions are calculated using data from both wet-weather conditions and combined wet- and dry-weather conditions and are presented in Table 2. These loading reductions (if required) were calculated for all stream segments in the Palmer River basin, based on data collected at the sample stations included in the ESS (2003A and 2003B) studies and previous studies by MADEP (1999), MDMF (1997), and RIDEM (2002) (see Section 4.1.1).

Examination of wet-weather data separately provides estimates of magnitudes of reductions from all sources during wet-weather conditions. As indicated in Table 2, in some sub-basins, bacteria reductions of 1 to 2 orders of magnitude [e.g., 2,000 to 200 (1 order of magnitude); 20,000 to 200 (2 orders of magnitude)] are needed to meet water quality standards. For example, when viewing the data in Table 2 at station FB02 (the worst case in the watershed), a reduction of close to 100% is needed to reduce fecal coliform levels to meet water quality standards during wet-weather conditions. The 90% observation listed in the table means that 90% of the samples collected at this station fall below the value of 220,000 cfu per 100 ml. That value would have to be reduced to 400 organisms per 100 ml to meet water quality criteria. This translates to nearly a 100% reduction. The 90% observation was calculated as follows:

- For sites with 10 or more sample points, the 90th percentile value was used; and
- For sites with less than 10 sample points, the highest value was used.

7.2.1 Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the influent water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling that are known to occur.

7.2.2 Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Bacteria sources to the Palmer River arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical condition that is protective for all other conditions. For example, leaking septic system contributions are assumed to be relatively constant over time, and their control will be most critical during drought conditions. Agricultural runoff, on the other hand, will be most critical during wet-weather periods. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts fecal coliform standard independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that are necessary will be in place throughout the year, protecting water quality at all times.

8.0 IMPLEMENTATION ACTIVITIES AND FUTURE MONITORING

Several sub-basins in the Palmer River watershed stand out as likely priority areas to address bacteria pollution sources. These sub-basins tend to be located in the southern and western portions of the watershed, where relatively dense residential development is increasing, major roads and highways are present, intensive agriculture is practiced, golf courses and the waterfowl that frequent them are plentiful, and stream channels are less buffered by forested and otherwise vegetated zones than they are in the upper Palmer River basin. Based on the findings of the ESS (2003A) NPS assessment, the following sub-basins should be focused on for future NPS abatement efforts: the Fullers Brook (FB03), Rumney Marsh Brook (RB02), Beaver Dam Brook (BB 01), Clear Run (CR03), Torrey Creek (TC01), and Rocky Run (RR06). Watershed stewards may also want to focus growth management initiatives in the upper Palmer, to prevent the degradation of areas that now appear to be functioning relatively well.

EOEA and MADEP staff work should continue to work with the communities in the Palmer River watershed as well as appropriate government agencies and organizations such as the Massachusetts Department of Agricultural Resources (formerly DFA), the Palmer River Watershed Alliance, and Save the Bay to identify and seek support for the priority recommendations for reducing nonpoint source pollution identified in this report. Non-structural BMPs such as improved cattle fencing and feeding operations are recommended for many parts of the Palmer River watershed where agricultural runoff is a primary source of bacteria contamination. Stream bank, riparian wetland, and floodplain restoration would parts of the watershed where residential development and roadways (e.g., Interstate 195) impact the riparian zone. Structural BMPs, although often cost intensive, may be appropriate for areas of imperviousness whose runoff cannot otherwise be addressed. And septic system investigations at the local level would benefit several areas of the watershed identified as potentially problematic.

The data supporting this TMDL indicate that bacteria enter the Palmer River from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include:

- Septic tank controls
- Agricultural BMPs
- Documentation of storm drain outfall locations
- Watershed resident education
- Additional monitoring

8.1 Septic System Controls

Septic system bacteria contributions to the Palmer River may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title V, which requires inspection of private sewage disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future.

From the Massachusetts DEP website, several steps which can be taken to maintain a properly operating septic system include:

(Website address http://www.magnet.state.ma.us/dep/brp/files/yoursyst.htm))

- DO have your tank pumped out and system inspected every 3 to 5 years by a licensed septic contractor (listed in the yellow pages).

- DO keep a record of pumping, inspections, and other maintenance.

- DO practice water conservation. Repair dripping faucets and leaking toilets, run washing machines and dishwashers only when full, avoid long showers, and use water-saving features in faucets, shower heads and toilets.

- DO learn the location of your septic system and drainfield. Keep a sketch of it handy for service visits. If your system has a flow diversion valve, learn its location, and turn it once a year. Flow diverters can add many years to the life of your system.

- DO divert roof drains and surface water from driveways and hillsides away from the septic system. Keep sump pumps and house footing drains away from the septic system as well.

- DO take leftover hazardous household chemicals to your approved hazardous waste collection center for disposal. Use bleach, disinfectants, and drain and toilet bowl cleaners sparingly and in accordance with product labels.

- DON'T allow anyone to drive or park over any part of the system. The area over the drainfield should be left undisturbed with only a mowed grass cover. Roots from nearby trees or shrubs may clog and damage your drain lines.

- DON'T make or allow repairs to your septic system without obtaining the required health department permit. Use professional licensed septic contractors when needed.

- DON'T use commercial septic tank additives. These products usually do not help and some may hurt your system in the long run.

- DON'T use your toilet as a trash can by dumping nondegradables down your toilet or drains. Also, don't poison your septic system and the groundwater by pouring harmful chemicals down the drain. They can kill the beneficial bacteria that treat your wastewater. Keep the following materials out of your septic system:

    - NONDEGRADABLES: grease, disposable diapers, plastics, etc.

    - POISONS: gasoline, oil, paint, paint thinner, pesticides, antifreeze, etc.

8.2 Agricultural Best Management Practices

Agricultural BMPs will be required in several sub-basins studied and included in this TMDL, including Fullers Brook and Torrey Creek. These BMPs include improved manure management facilities, fencing of livestock to keep them from grazing (as well as defecating and eroding soils) in vegetated stream buffers, engineered grassy swales to slow and infiltrate runoff, and other barnyard runoff controls. These measures should be undertaken by local farm owners, in conjunction with town and Department of Agricultural Resources (formerly DFA) officials.

8.3 Documentation of Storm Drain Outfall Locations

Rehoboth and Swansea are Phase II communities subject to the requirements of EPA's NPDES Phase II General Permit for MS4s. Mapping of storm drains (or drainage concentration areas) as well as other required compliance measures should be undertaken by these towns to better identify potential sources of NPS pollution and assist in the design and implementation of in-line BMPs.

8.4 Watershed Resident Education

Outreach programs for residents to encourage improved pet waste management should be encouraged. These programs would best be implemented by the towns in conjunction with the River Watershed Alliance and Save the Bay.

8.5 Wildfowl Control Measures

Reducing mown grassy areas adjacent to streams and maintaining stream buffers vegetated with native plants is one of way of controlling bacteria inputs from wildfowl. More aggressive wildfowl control measures involving noise, scents, and controlled hunting may also be considered. These programs would best be implemented by town conservation agents.

8.6 Additional Monitoring

Future water quality monitoring in the Palmer River basin will be useful in order to monitor trends in bacteria concentration and verify that implementation of controls is leading to compliance with water quality standards. This monitoring could be conducted on a seasonal basis, structured to include at high-flow and one low-flow periods. These programs would best be implemented by town conservation and health agents, with assistance from the River Watershed Alliance, Save the Bay, and MADEP. MADEP will also continue to monitor water quality in the watershed through its rotating basin assessment cycle.

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